ISSUE BRIEF

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# Stormwater Capture Potential in Urban and Suburban California

Communities throughout California are facing serious and growing threats to their ability to provide a safe, reliable supply of water. Drought, coupled with over-allocation of existing water sources, is affecting cities, farms, businesses, industries, and the environment all across the state. For many communities, 2013 was the driest year in a century, and the lack of precipitation has critical implications for the continued viability of surface water and groundwater resources that supply our cities. The long-term effects of climate change are likely to exacerbate this. Capturing and using or storing stormwater runoff when it rains can help communities increase water supply reliability—so they have the water they need when it doesn't.

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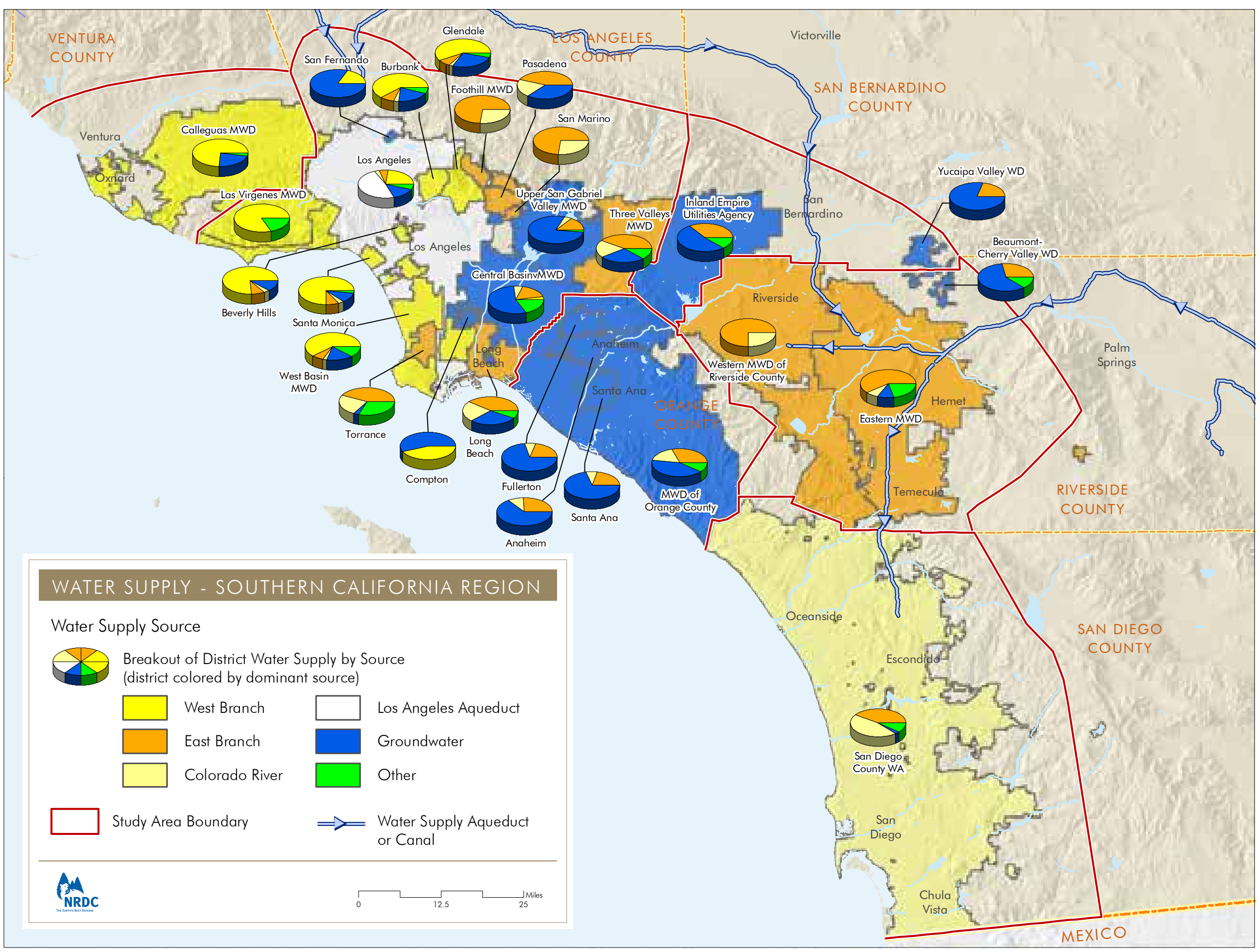
Capturing stormwater runoff from impervious surfaces in urban and suburban areas when it rains—whether by directing the runoff to open spaces and allowing it to infiltrate into the ground to recharge groundwater supplies or by harvesting the runoff, primarily from rooftops, in rain barrels and cisterns for direct use in nonpotable applications—can be used to increase California's water supplies dramatically. In southern California and the San Francisco Bay Area, capturing runoff using these approaches can increase water supplies by as much as 630,000 acre-feet each year. Capturing this volume, roughly equal to the amount of water used by the entire City of Los Angeles annually, would increase the sustainability of California's water supplies while at the same time reducing a leading cause of surface water pollution in the state.

## STORMWATER RUNOFF, CAPTURE, AND WATER SUPPLY

When it rains on undeveloped lands, much of the rainwater either soaks into the ground or evaporates. Critically in this system, water that is not taken up by plants can infiltrate below the surface and help add to, or recharge, groundwater aquifers—vast stores of water that fill in the voids, pores, or cracks in soil or rocks underground. Groundwater has been used to supply growing communities in Southern California for more than 150 years, and today it fills approximately 40 percent of the region's overall water needs (Figure 1—showing water supply sources for water districts in Southern California including local groundwater production and imported water sources such as the Colorado River and the East and West branches of the State Water Project) (NRDC 2009). It is also used extensively in other portions of the state, supplying communities in the Central Coast, portions of the San Francisco Bay Area, throughout the Central Valley, and into the Shasta-Cascade region.

However, as California's population has grown and more and more land has been developed or redeveloped, much of the natural landscape in these developed areas has been paved over, drastically altering the hydrologic regime that replaces and recharges groundwater. When it rains on urban and suburban landscapes, impervious surfaces like streets, sidewalks, rooftops, and parking lots prevent the water from soaking into the ground. This cuts off groundwater aquifers from a principal supply source and

**Figure 1. Water supply sources and dominant source type for water districts in Southern California**




*Source:* NRDC 2009

A vegetated swale in a parking lot
© Haan-Fawn Chou

leaves the water with nowhere to go but downhill. Instead of adding to our groundwater supplies or nourishing plant life, it picks up animal waste, trash, metals, chemicals, and other contaminants in its path, ultimately dumping the pollution into rivers, lakes, or ocean waters. At the same time, the drastically increased volume of runoff can lead to increasingly severe flooding and erosion. And even when it isn't raining, water from excess landscape irrigation, car washing, industrial processes, and other uses flows into storm sewer systems—an estimated 10 million to 25 million gallons flow into Santa Monica Bay alone for each dry-weather day (City of Los Angeles 2009), and more than 100 million gallons flow to the ocean from across Los Angeles County (City of Los Angeles BOS). Altogether, hundreds of billions of gallons of potential water supply are thrown away each year in a manner that endangers public health and ecosystems, and weakens coastal and other economies that depend on clean water for tourism revenue.

"Green infrastructure" is an approach to water and stormwater management that, among other goals, aims to maintain or enhance the pre-development or natural hydrology of urban and developing watersheds. It includes a wide variety of practices that can be used to capture stormwater runoff to increase water supplies at both a distributed (or on-site) scale and at subregional or regional scales. Green infrastructure may be used to promote infiltration of water into the ground, where it can recharge groundwater supplies, or to promote its capture in rain barrels and cisterns for later use. Many California cities and towns are already using a combination of distributed and regional practices to capture stormwater and put it to use.

There is a tremendous need, and opportunity, to capture more stormwater as a way to sustainably increase water supplies. For example, a one-inch rain event in Los Angeles County can generate more than 10 billion gallons (roughly 30,000 acre-feet) of stormwater runoff, most of which ultimately flows into the Pacific Ocean. In the Central and West Coast groundwater basins on the coastal plain of Los Angeles, approximately 54,000 acre-feet of rain and stormwater runoff per year are currently captured and recharged, primarily by the Los Angeles County Flood Control District (Johnson 2008). But the Water Replenishment District of Southern California, which manages the groundwater basins, also must import roughly 30,000 acre-feet of water per year to make up for excess groundwater pumping by water rights holders. At the same time, an estimated 180,000 acre-feet of stormwater runoff is lost to the ocean each year from its service area (Water Replenishment District 2012), representing a lost opportunity to increase local water supplies.

## QUANTIFYING THE POTENTIAL FOR STORMWATER CAPTURE

In 2009, NRDC and the University of California, Santa Barbara conducted an analysis of the potential stormwater capture for water supply that could be achieved at new building projects and redevelopment projects for residential and commercial properties in urbanized Southern California and the San Francisco Bay Area. Focusing on opportunities for either infiltration of runoff to recharge groundwater resources or rooftop rainwater capture for on-site use, the study found that stormwater capture could increase overall water supplies by up to 405,000 acre-feet per year by 2030 (NRDC 2009). However, that analysis did not address stormwater runoff from existing development, by far the largest source of runoff, and was limited in the types of land use it considered. As a result, while demonstrating a robust potential to increase water supply through stormwater capture, the analysis was conservative in its assessment of the overall potential for stormwater capture.

To inform ongoing discussions about the drought and pressing challenges for the California water supply sector, we have updated this analysis using new data in order to provide a more comprehensive picture of the potential for stormwater capture to augment local water supplies. The analysis again focused on urbanized Southern California and the San Francisco Bay Area, as the two most heavily urbanized and developed regions of the state; combined, they account for approximately 75 percent of California's population.

For this analysis, we calculated the potential water supply that could be captured from existing impervious surfaces in urban and suburban landscapes through infiltration or rooftop rainwater harvesting on the basis of a GIS analysis of selected land uses and impervious surface cover.[1] Calculations for runoff were based on an analysis of total impervious cover and average annual precipitation for each land use type.[2]

In addition to precipitation-based runoff, dry-weather runoff from human activities, such as landscape irrigation

**Figure 2. Map of impervious surface cover within the San Francisco Bay Area study area**

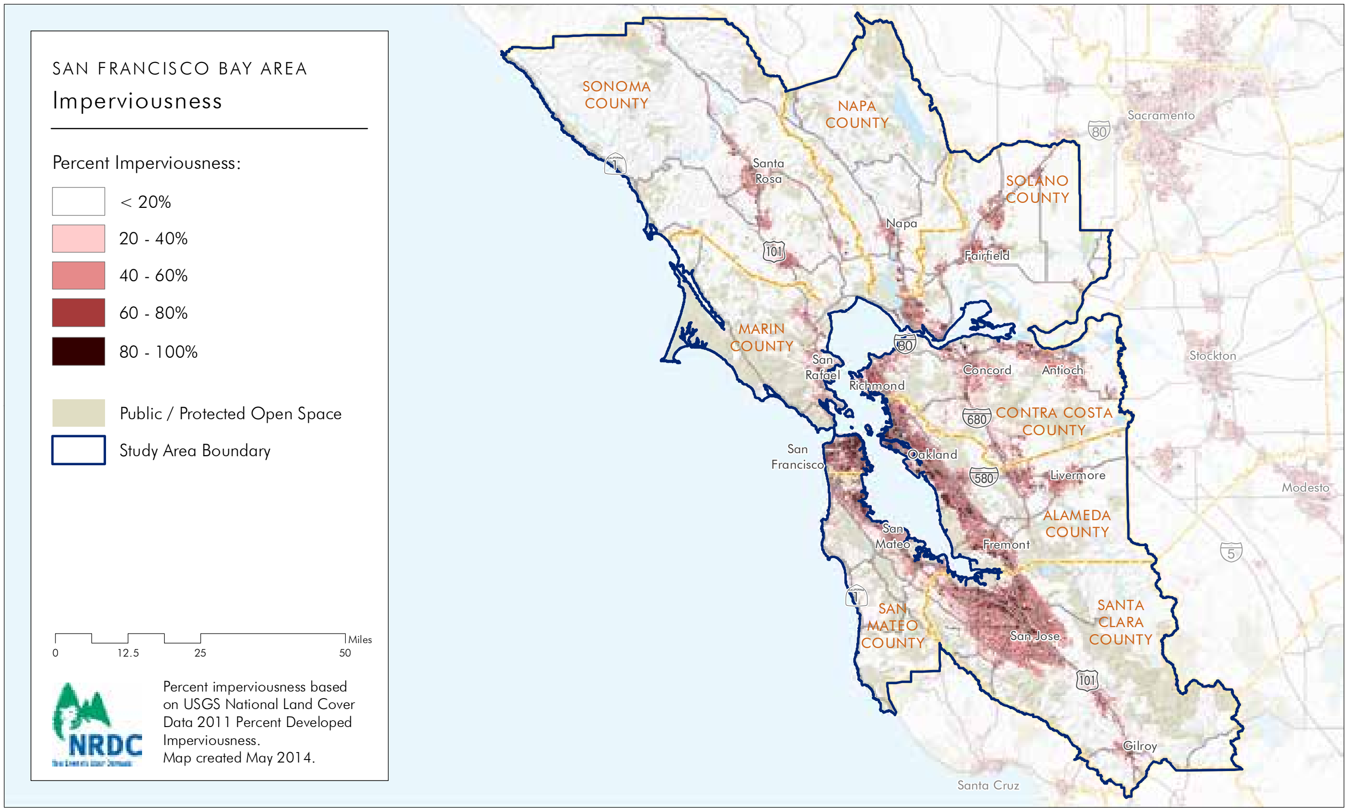
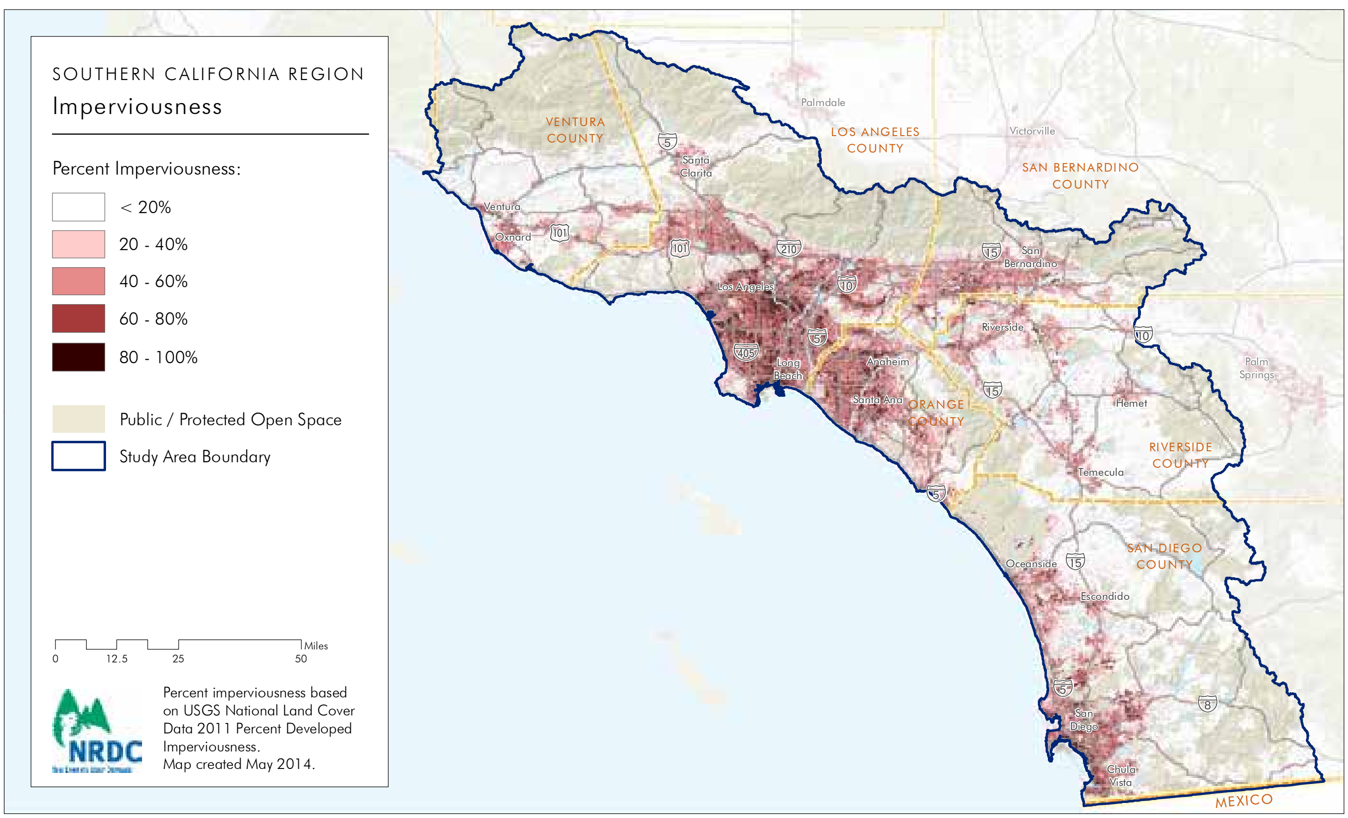



**Figure 3. Map of impervious surface cover within the Southern California study area**



Left: A drainage swale as part of the City of Seattle's Street Edge Alternatives project
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Right: A rain barrel in Santa Monica
© EPA/Abby Hall

and car washing, that overflows onto paved surfaces can also be captured. On the basis of a 2004 study by the Irvine Ranch Water District, we assumed that dry-weather runoff resulting from over-irrigation and other processes for residential and commercial developments is 0.152 gallon of runoff per acre of pervious surface (landscaped area) per minute on days when it does not rain. Importantly, however, our analysis did not assess the potential for additional capture that could be achieved for runoff from open space, or for runoff from surrounding areas that may flow into urban and suburban landscapes. Because the study considered only runoff from developed lands, it is likely still conservative with respect to the total volume of runoff available for capture.

Land use was also analyzed to assess whether development was located over a groundwater aquifer currently used for municipal water supply, such that infiltration would add to an existing supply source, and to identify soil or geologic conditions that could obstruct runoff from infiltrating to a depth necessary to reach these aquifers. Within these areas, where conditions are favorable for infiltration, the analysis assumed that for highly infiltrative soils (NRCS Hydrologic Soil group A or B), between 75 and 90 percent of the runoff could be infiltrated into the ground. The analysis assumed that the remaining portion of runoff would be lost to evaporation or transpiration during conveyance of the runoff to its infiltration point or due to the drawdown time required for the water to fully infiltrate. Where infiltrative capacity of the soils is suitable for recharge, but where soil conditions require a longer drawdown time for the water to infiltrate (e.g., NRCS group C soils), the analysis assumed that 65 to 80 percent of the runoff could be infiltrated into the ground. Where highly non-infiltrative soils such as those with a high clay content are present (e.g., group D soils), or where development has occurred outside of areas underlain by a groundwater basin used for water supply, the analysis assumed that rooftop rainwater harvesting would be the method of capture used.

Existing groundwater pollution or the presence of shallow groundwater could serve as additional obstacles to using practices that increase groundwater recharge, as increased infiltration could in some circumstances result in flooding or mobilization of groundwater pollutant plumes. For example, portions of the San Fernando and Main San Gabriel groundwater basins in Los Angeles County are contaminated by such pollutants as the volatile organic compounds trichloroethylene (TCE) and perchloroethene (PCE); this complicates efforts both to make use of the basins' resources and to recharge groundwater supplies (Sahagun 2013). However, the opportunity presented by stormwater capture offers a strong incentive to clean up and restore these groundwater resources where they are impaired.

Where infiltration is not feasible, the analysis assumed on-site rooftop rainwater harvesting would be used to supply water for nonpotable uses such as outdoor irrigation and toilet flushing. The analysis considered only those land uses that were likely to have use for captured water on-site, such as residential development or commercial/office development with landscaping or building occupants sufficient to make use of the water. The analysis assumed, at the low end, that a single-family residential parcel would use one 55-gallon rain barrel for capture and on-site use— providing an average of 660 gallons of water per year, based on 12 refill events (Santa Monica Bay Restoration Commission and Great Ecology 2012). While our higher end capture estimate for single family homes is based on an assessment of the amount of rooftop runoff that could be harvested and used per unit roof area (see below), even small, simple rooftop rainwater harvesting systems such as rain barrels can create a large overall water supply benefit when use is widespread within a community. Rain barrels provide a generally known range of annual capture volume based on the number of refill events regardless of roof size, and thus for our low end estimate we base the amount captured for any individual single family home on a set volume, rather than on a percentage of annual rooftop rainfall. Our low-end estimate also assumed that multifamily, commercial, and government or institutional development would use an average of 25 percent of annual rooftop runoff in Southern California and 35 percent in the San Francisco Bay Area.[3] At its upper end, the analysis assumed that in Southern California, single-family residences would capture 35 percent of annual runoff for water supply, while multifamily residential, commercial, and government or institutional development would capture 45 percent of annual runoff for water supply. In the San Francisco Bay Area, the percentages assumed for the upper end case were 40 percent for single-family homes and 55 percent for residential, commercial, and government or institutional development.

## URBAN STORMWATER CAPTURE POTENTIAL: FINDINGS AND ANALYSIS

Overall, we estimate that stormwater capture in urbanized Southern California and the San Francisco Bay region has the potential to increase water supplies by 420,000 to 630,000 acre-feet per year, at its upper end approximately as much water as used by the entire city of Los Angeles each year.

Infiltration, whether conducted at a distributed scale or through regional groundwater recharge projects, has the capacity to capture large volumes of water on both individual storm and annual time frames. As a result, it represents the greatest stormwater-based opportunity to increase water supplies for our cities. In areas overlying groundwater basins used for municipal water supply, our analysis found that between 365,000 and 440,000 acre-feet of runoff could be captured and stored for use each year. Projects designed for large-scale capture, including use of green streets (designed to manage stormwater runoff in the public right-of-way), park retrofits, government building or parking lot retrofits, and infrastructure changes to divert runoff to large-scale spreading grounds, offer substantial opportunity for cities to increase local supplies of water throughout California. Cities can additionally incentivize action on private property to increase infiltration, such as through downspout disconnection programs and landscape retrofits.

We also note that in areas not identified by the study as ideal for infiltration—for example, because of the presence of soil or geology that would inhibit the ability of water to percolate sufficiently deep to reach groundwater resources used for water supply—our cities will nevertheless generate hundreds of thousands to millions of additional acre-feet of stormwater runoff annually. Though not analyzed in this study, substantial opportunity exists to use parks or other open spaces to capture much of this runoff, in large-scale cisterns or detention basins, and put it to use for on-site irrigation or as part of neighborhood- or regional-scale nonpotable distribution systems (Community Conservation Solutions 2008). As a result, the figures presented above for municipal opportunity are likely conservative in terms of the volume of runoff that could actually be captured for water supply.

Where infiltration is not the preferred means of increasing water supplies, rooftop rainwater capture could be used to increase water supplies by as much as 190,000 acre-feet per year, of which nearly 145,000 acre-feet could be gained via rainwater capture systems installed in our homes. This amount could be even greater if rooftop rainwater capture were also used in areas where infiltration and groundwater recharge are feasible. Overall, however, on-site rooftop rainwater harvesting for residential buildings has the potential to add between 30,000 and 145,000 acre-feet of water supply per year that could be used for landscape irrigation, toilet flushing, or other nonpotable applications. The wide difference between the two estimates is driven largely by assumptions made for capture practices employed at single-family homes, which constitute by far the largest residential land use in both study areas. Capturing a portion of the runoff from single-family homes for on-site use, however, would drastically increase overall local water supplies and reduce strain on existing systems.

## CONCLUSIONS

Our findings make it clear that stormwater capture, using both infiltration to recharge groundwater resources and capture of rooftop runoff for direct nonpotable consumption, is a strong option for improving the resilience and sustainability of water supply for the cities and suburban areas of California.

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## Endnotes

1 For example, residential, commercial, and institutional uses, as well as roads, were analyzed; airport, military, and heavy industrial uses were not.

2 The analysis used a runoff coefficient for impervious surfaces of C = 0.009 * I + 0.05, where I is the impervious percentage (with I = 100 percent for fully impervious areas) (Schueler 1987). This is essentially equivalent to 95 percent of precipitation falling on paved surfaces mobilizing as runoff.

3 Recent analysis by Geosyntec Consultants found that, using a representative rainfall record for the Los Angeles area, where one-half gallon of storage capacity is provided per square foot of roof area (e.g., a 500-gallon cistern for a 1,000-square-foot roof), 35 percent of annual runoff could be captured assuming a 360-hour (15-day) drawdown time to empty the cistern, and 43 percent of the annual rainfall could be captured assuming a 180-hour (7.5-day) drawdown time. For the San Francisco Bay Area, the analysis found that for the same storage capacity, 41 percent of annual rainfall could be captured assuming a 360-hour drawdown time, and 56 percent could be captured assuming a 180-hour drawdown time (Geosyntec 2014) areas or land uses with higher consumption rates would have a higher harvesting and use potential.

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